

Thermal Conductivity and Elastic Constants of Porous HSQ Low-k Dielectrics

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We have measured the thermal conductivity and elastic constants of dense and porous hydrogen silsesquioxane (HSQ) thin films developed by Dow-Corning for applications as low-k "spin-on" interlayer dielectrics. HSQ has a nominal composition of $\text{HSiO}_{1.5}$ "Flowable oxide" (FOx) is an essentially dense form of HSQ (1.5 g cm^{-3}) and "extra low-k" (XLK) is HSQ with nanoporosity and reduced density (0.9 g cm^{-3}). The thermal conductivity of FOx and XLK thin films are measured using the 3-omega method in the temperature range 80-400 K; and the combination of RBS and ellipsometry gives the film density. Speeds of sound are measured using picosecond ultrasonics: subpicosecond optical pulses produced by a mode-locked Ti:sapphire laser are used to generate and detect high-frequency longitudinal acoustic waves. We find remarkably good agreement between the measured thermal conductivities of FOx and XLK and their predicted minimum thermal conductivities.